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Survey of Tests Used in Airman Classification

By
William B. Lecznar

Technical Documentary Report PRL-TDR-63-5
February 1963

6570TH PERSONNEL RESEARCH LABORATORY
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
Lackland Air Force Base, Texas

Project 7717, Task 771705

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FOREWORD

This publication has been prepared as a means of providing a view of the enlisted selection and classification process—the tests in being, how they are assembled, who develops them, the way that scores are actually used, the efficiency of the tests, and some research that backs up successive forms of a test. The material has been compiled largely from other publications issued by the Personnel Research Laboratory and its predecessor Air Force organizations. Personal credits to the authors of these reports appear throughout this paper.

ABSTRACT

Aptitude tests have been used since 1948 to aid in selecting and assigning enlistees to the training for which they are best suited by ability and education. By this means the Air Force seeks to reduce the cost of training and realize competent, well-satisfied career airmen. This survey traces the history of airman aptitude testing, tells how effective tests are identified, how the tests are assembled, and how the scores are used. The present Airman Qualifying Examination is described and compared with other aptitude test batteries. The role of research in seeking out more effective techniques of personnel selection and assignment is emphasized, with illustrations from ongoing studies.

This report has been reviewed and is approved.

Fred E. Holdrege, Col, USAF
Commander

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Technical Director

Hq 6570th Personnel Research Laboratory

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INTRODUCTION

In the past few years, and particularly since early 1958 when a program of selective recruiting was initiated, an increasing number of people have become more directly involved with the United States Air Force program of testing enlisted personnel for selection and classification purposes. When this testing was a part of the early processing of a new recruit at the basic military training center, a limited number of persons were directly concerned with the tests, their administration and use. In April 1958, the USAF Recruiting Service was given responsibility for selective recruiting. Administration and scoring of selection and classification tests was made a part of that mission. In the interests of obtaining the best qualified individuals for enlistment in the Air Force, the Recruiting Service has approached many persons in communities across the United States for assistance. To some of these people, the tests used by the Air Force to select the best potential enlistees from among the many possible applicants are an unknown quantity.

A product may sell once because of a fancy package or through an intensive advertising campaign, but it gets repeat sales because of its own merits. For those readers who want to know more about the Air Force classification tests this report has been prepared to show some of the "inside of the package." The material has been collected into four major areas. Section I is directed to a brief history of the testing program. Section 2 relates the Air Force tests and jobs to the civilian technology and commercial tests. Section 3 gives some technical data for the Air Force test batteries. Section 4 looks at research in progress that provides inputs for revision of the tests to come. The report will answer such questions as: "Why does the Air Force test a potential enlistee?" "Who builds the tests?" "How are they built?" "How are the scores used?"

SECTION 1. ORGANIZATION AND PERSONNEL

Historical Antecedents

The airman classification program of the 1960's traces its ancestry to the aviation cadet program of the 1940's. From the Army Air Forces Aviation Psychology Program of World War II came a number of the techniques and test ideas on which the present Airman Classification Test and the Airman Qualifying Examination are based. From the integrated research and development program on aptitude tests for classification of aircrew personnel started in 1941 there has been continuity to the present day of an Air Force organization engaged in personnel research; as a matter of fact, a few of the workers in the World War II program are today still active in the test research and development program of the Air Force.

The Personnel Research Laboratory is the Air Force research unit for personnel measurement and evaluation and is under the Air Force Systems Command. It is of considerable significance that this activity represents the thread of continuity from the Aviation Psychology Program of World War II through the postwar years to the present time. In spite of the many organizational changes and budgetary considerations, the Personnel Research Laboratory has maintained its mission, status, and scientific environment since 1946. There have been fluctuations in the level of operating resources, but the building of tests for use in the selection and classification of Air Force officer and enlisted personnel has been the core of laboratory activity.

The Present Staff

A major factor in this continuity may be attributed to the professional and scientific background of the individuals on the staff. The philosophy of a maximum of professional training in psychology and education defined in the manning of the Psychological Research Units in 1941 established a precedent that has carried through to the present. Whether military or civilian, most persons engaged in the direction of test research and development have had not less than an MA degree with a major in Psychology or Education and many have earned the PhD degree from recognized American universities. In the period from 1946 to 1952, much of the writing of test items was done by the in-service staff; in more recent years, quantities of test items for the various types required for selection and classification batteries have been obtained through research and development contracts with agencies such as Test Research Service (New York), Human Factors Research (Los Angeles), Science Research Associates (Chicago), and Educational Testing Service (Princeton). On two occasions the test batteries were developed under contract; the Airman Classification Battery, Form AC-1C, was built by the Educational Testing Service and the Airman Qualifying Examination, Form 62, was assembled by the American Institute for Research.

SECTION 2. AIR FORCE TESTS RELATED TO CIVILIAN TESTS

Factor Approach to Classification Tests

The airman selection and classification tests have been oriented toward the objective of providing measures of aptitude for predicting completion of technical training. The development of the first Airman Classification Battery was based on two premises: (a) that each job specialty, designated by an Air Force Specialty Code (AFSC), requires a different combination of aptitudes for success; and (b) that this specific combination of aptitudes will better predict success for a given specialty than would a general intelligence or general classification test. Although the theory of a separate pattern of aptitudes for each job specialty (training course) suggests a large number of patterns, in practice it was found that some of the patterns are highly similar. Consequently it was possible to combine those specialties requiring similar patterns of aptitudes into homogeneous clusters or groups. The earliest battery yielded scores for eight such groups; later revisions and research reduced this number to five, one of which was a highly specific set of aptitudes best measured by inclusion of some aural tests. The present Airman Qualifying Examination, described more completely in a later section, has composite scores for four areas or specialty groupings.

In general, the tests comprising a battery were each designed to measure a single factor, insofar as this was possible. The limits of testing time available required the use of short tests in order to represent the major factors that were present in the criteria being predicted. It has been demonstrated, however, that although the reliability of any one short test may be less than desired, when several short tests are combined into a composite, the reliability of the composite is well within the range of expected and accepted values (Brokaw, 1950). This principle is used in such commercial aptitude test batteries as the Employee Aptitude Survey and the Differential Aptitude Tests.

As a matter of interest, the factor content of a number of commercial tests is compared with the Air Force battery in Table 1. It is apparent that nearly all of these instruments are similar in the basic six or seven factors; the remaining factors tend to be specific to particular batteries. In prediction of Air Force technical training success, the Space Relations and Memory factors have not appeared as significant abilities. Further, recent research suggests that the Motor Speed and Coordination factors cannot be measured adequately with paper-and-pencil tests (Fleishman & Ellison, 1962). For the general run of the more commonly encountered Air Force jobs, the AQE represents a satisfactory test coverage of aptitude factors.

TABLE 1. **Factor Content of Several Aptitude Batteries**

Battery	Reported Factors											
	V	N	R	PS	SV	FP	Me	F	SR	Mm	C	MS
Airman Qualifying Examination	X	X	X	X	X	X	X					
Detroit General Aptitudes Examination	X	X	X	X			X	X	X			X
Differential Aptitude Tests	X	X	X	X	X		X	X				
Employee Aptitude Survey	X	X	X	X	X			X				X
Factored Aptitude Series	X	X	X	X	X	X	X	X	X	X	X	X
Flanagan Aptitude Classification Tests	X	X	X	X	X	X	X	X	X	X	X	X
Guilford-Zimmerman Aptitude Survey	X	X	X	X			X		X			
General Aptitude Test Battery (USES)	X	X	X	X	X	X					X	X

V = Verbal, N = Numerical, R = Reasoning, PS = Perceptual Speed, SV = Spatial Visualization, FP = Form Perception, Me = Mechanical, F = Fluency, SR = Spatial Relations, Mm = Memory, C = Coordination, and MS = Motor Speed.

How is Aptitude Information Presented?[1]

Aptitude indexes from the Airman Qualifying Examination appear as a percentile type of score, with the potential mobilization population broken into 20 equal parts, each covering 5 percent of the range of talent. The mobilization population refers to the entire range of talent available under wartime enlistment conditions. Each such 5-percent block is designated by a number indicating the percentage of the mobilization population falling below the block. For this reason the highest possible score is 95, indicating the 5 percent achieving the highest scores. The lowest possible score would be zero, indicating the 5 percent block inferior to the other 95 percent of the sample. For convenience with electronic computing machines, the lowest score is given as 01 rather than as 00.

Aptitude indexes should be interpreted as indicating the location of a given individual, in terms of the percentage of individuals who would do less well, in a mobilization population, within the specific aptitudes measured by the indexes under consideration. For example, an individual with an Electronics index of 50 is just slightly above the average in possession of aptitudes related to success in electronic types of training; one with an index of 80 is quite high in aptitude; one with an index of 30 is quite low.

How Can Information About Aptitude Indexes Be Used?

The aptitude indexes are designed to predict success in training on an actuarial basis. As successively higher scores are achieved on a given aptitude index, the probability of the individual's success in training in that field rises. It must be remembered that success in training, like success on a given job, is a function, not only of aptitude, but also of motivation and individual characteristics of the worker and of the supervisor or teacher.

The Airman Classification Battery and the Airman Qualifying Examination produce information that is almost entirely aptitudinal in nature. Interest and motivation toward success in a certain field is taken into account, to some extent, by the classification interviewer at the military training center. If the interviewer is skillful in his discussion, and if quotas permit, it is probable that at the time of assignment the airman was genuinely interested in the occupational field to which he is assigned. In such a job his motivation should lead to reasonable development of his aptitude potential.

[1] This section is based on an unpublished paper by F.D. Harding & L.D. Brokaw, Implications of Air Force personnel information for job requirements, *Technical Memorandum* PL-TM-58-3, February 1958.

Meaning of the Aptitude Indexes

The Mechanical Aptitude Index is primarily based on experience and interest in simple mechanical topics. Only those persons scoring high (80 or higher) in this index would possess information gained in elementary science courses. Most of the questions involve factual knowledge of machines or mechanical processes, some are based on pictures, others on verbal descriptions. Understanding of the functions of the moving parts of machines or of the problems of sheet metal work is assessed through questions covering relationships existing in simple geometric figures in which various parts have been transposed.

It has been found that the low (scoring 25 or below) aptitude airmen in this field depend more on rote knowledge and less on understanding of mechanical principles. They know how to do certain simple mechanical tasks, like straightening a bicycle wheel or lowering its seat, but cannot follow the direction of rotation through a gear train. Their vocabularies are normally quite restricted, both for technical mechanical words and for more literate terms.

The Administrative Aptitude Index represents performance on tests which stress speedy response to verbal and quantitative materials. Also included is a measure of the knowledge of the meanings of words. Scores on the Administrative Index are predictive of perfotmance in clerical activities which require attention to detail and fairly rapid work. In the speeded test of simple subtraction and division, low ability airmen attempt only about half the items and are quite inaccurate. They also tend to make more mistakes on division than on the subtraction problems.

The General Aptitude Index, as its name implies, covers general ability in much the same manner as did the Army General Classification Test in World War II. It is primarily a measure of general intelligence, and properly is used for assignment of men to those several fields which have been found to depend on balanced ability rather than high specialization in certain aptitudes. The indiscriminate use of this index for assignment purposes would result in serious losses through waste of talent of men of unique capabilities for the more highly specific fields. Tests in this measure include vocabulary, arithmetic reasoning, and hidden figures.

The Electronics Aptitude Index is the most technical in content, and is well described as a measure of engineering aptitude. It goes beyond informational material into understanding of the fundamentals of mechanics and electricity, as well as other physical principles. Persons scoring high on this index have demonstrated knowledge of electrical principles and ability to understand complex mechanical designs. A high score indicates ability to apply fractions, percentages, and simple formulas in solving mathematical problems. The ability to visualize the appearance of objects in various positions and with various changes in their structure is another important component of the Electronics Index.

The same general characteristics apply to low aptitude airmen in this area as in the mechanical area. They tend to lack understanding of principles, and to possess only fragmentary rote information; e.g., they know how to insulate bare wires, and can identify an automobile distributor. They tend to be inaccurate and careless. Low aptitude airmen, on the average, attempt to answer more of the arithmetic reasoning questions than do their more able fellows; yet they answer most of the questions incorrectly.

Relationship Between Aptitude and Occupational Level

The question as to just what a person of a certain aptitude level may be expected to do is difficult to answer. This is because other factors besides aptitude influence job performance. A person's interests, attitudes toward work, previous experience, kind of training received, supervision, all play a part in his level of job performance.

Another factor which needs to be considered is the nature of the job itself. If the work is fairly standardized and does not require learning from new experiences, then it might be

expected that less able people with additional training or experience could perform as well as those who are more intelligent.

While there are no studies which relate aptitude levels directly to performance of various tasks, it is possible to get indications of the relationship of general intelligence level and occupational level. Pertinent information showing this relationship is presented in the next two tables.

TABLE 2. Estimated Level of General Intelligence Typical of Certain Jobs[a]

(Based on ratings by USES)

General Aptitude Index	Job Title
95	Accountant, General
90	Radio Engineer
85	
80	Electrical Equipment Tester
75	Radio Operator, Flight
70	
65	
60	Airplane and Engine Inspector
55	Office Machine Serviceman
50	Radio Repairman I
45	
40	
35	
30	No Benchmark Jobs
--	
--	

Brief Job Descriptions

Accountant, General. Devises and installs accounting systems: Must be able to adjust a particular accounting system to the needs of a particular firm. Supervises subordinates. Balances books periodically and prepares statements showing such items as receipts, disbursements, expenses, and profit and loss. Prepares Federal, State or local tax returns.

Radio Engineer. Supervises operation of technical equipment in a radio or television station. Supervises maintenance or maintains station equipment in operation by rapid diagnosis, adjustment and repair of faults. Develops, constructs and installs new equipment for station.

Electrical Equipment Tester (aircraft mfg). Tests and adjusts electrical airplane equipment and accessories prior to installation, using special testing equipment and hand tools. Removes accessories or equipment such as solenoids, booster coils, condensers, etc. Connects special testing devices.

Airplane and Engine Inspector. Checks all parts and accessories of transport planes before and after flight and during overhaul, and certifies to the airworthiness of inspected airplanes. Tries tightness of connections, checks fit of parts, checks all factors which affect operation of aircraft. Notes all repairs found necessary and rechecks after work is done. Certifies and bears responsibility for airworthiness.

Radio Operator, Flight. Operates radio and direction-finding equipment aboard aircraft in flight. Maintains contact with ground stations by operating radio sending and receiving equipment using hand key and Morse code. Adjusts transmitters in airplane making minor repairs when feasible. Inspects equipment on ground doing all maintenance work except major repairs using test instruments and hand tools.

Office Machine Serviceman. Inspects, adjusts and repairs office machines such as adding, calculators, bookkeeping, multigraph and typewriters. Diagnoses the defect by inspection, by disassembling and examining moving parts.

Radio Repairman I. Tests and repairs defective radios: tests circuits, tubes and other parts using test meters and devices: Isolates defects and either fixes them or replaces parts. Resolders loose connections.

[a] From an unpublished paper by F.D. Harding & L.D. Brokaw, Implications of Air Force personnel information for job requirements, Technical Memorandum PL-TM-58-3, February 1958.

TABLE 3. Typical Intelligence Levels for Selected Civilian Occupations[a]

Occupation	Appropriate General AI[b]	Occupation	Appropriate General AI
Chemist	90	Airplane Mechanic	65
Draftsman	85	Electrician	65
Pharmacist	85	Sheet Metal Worker	60
Tabulating Machine Operator	85	Plumber	65
Installer, Telephone and Telegraph	75	Pipefitter	55
Instrument Repairman	75	Welder	55
Toolmaker	70	Tractor Driver	50
Machinist	70	Crane Hoist Operator	50
Watchmaker	65		

[a] From an unpublished paper by F.D. Harding & L.D. Brokaw, Implications of Air Force personnel information for job requirements, Technical Memorandum PL-TM-58-3, February 1958.

[b] The values presented here are for civilian incumbents of these jobs and are converted from World War II studies.

Description of Subtests in AQE-F

Form F of the Airman Qualifying Examination is similar in subtest content to Form D and Form 62 (introduced October 1962). The AQE content has followed that of the more comprehensive Airman Classification Batteries, with revisions suggested as a result of validation and research. The following item types comprise Form F of the Airman Qualifying Examination.

Arithmetic Reasoning. Verbally presented problems requiring the examinee to derive his own method of solution with a minimum of routine arithmetic computation.

Verbal Test. A relatively pure measure of academic vocabulary.

Mechanical Principles. Items covering the actions of mechanisms in motion and the principles pertaining to use of various mechanical devices.

General Mechanics. Items cast in verbal form as a measure of mechanical information and experience.

Tool Functions. Pictorial items of various tools and shop equipment oriented toward knowledge of the appropriate tool and its proper use for a given job.

Hidden Figures. A spatial measure requiring the discovery of one of several straight-line figures imbedded in a more complex figure.

Clerical Matching. Clerical speed and accuracy in the traditional form of matching pairs of symbols.

Numerical Operations. Arithmetic computations on subtraction and division as an indicator of numerical facility.

Electrical Information. Elementary fundamentals of practical and academic information on electricity.

Pattern Comprehension. A flat pattern with a drawing of a 3-dimensional object made from the flat pattern. The task requires identification of certain sides of the flat pattern with the sides of the 3-dimensional drawing.

Technical Data Interpretation. Extracting relevant data from charts and tables for use in the solution of simple problems.

Table 4 shows how these tests are combined to derive the aptitude indexes. Of possible interest to the counselor, the four composite scores of the Airman Qualifying Examination could be used in much the same way that the commercial aptitude test battery scores are used. The four aptitude areas of the AQE are job oriented; the Airman Classification Manual (AFM 35-1) and the USAF Training Prospectus relate training courses and job specialties to suggested minimum aptitude levels. Through the USAF Occupational Handbook, major job areas in the Air Force are related to the civilian technology as defined in the Dictionary of Occupational Titles (DOT). There is then a way to go from Air Force jobs and the AQE scores to the civilian job structure.

Although individual subtest scores are not presently derived in the scoring of the Airman Qualifying Examination, it is possible to do so. Through these individual scores a profile of aptitude factors could be prepared for more detailed counseling and guidance purposes if that were desired. The point is that the individual constituent tests, although in themselves rather short for high reliability, could be used in much the same manner as civilian aptitude test batteries.

TABLE 4. Content of the Airman Qualifying Examination, Form F

Subtest	No. of Items	Scoring Formula	Aptitude Index			
			M	A	G	E
Clerical Matching	50	R-W		x		
Numerical Operations	80	R-W		x		
Arithmetic Reasoning	15	R		x	x	x
Verbal Test	29	R		x	x	
Mechanical Principles	15	R	x			
General Mechanics	14	R	x			
Tool Functions	15	R	x			
Hidden Figures	16	R	x		x	
Electrical Information	15	R				x
Pattern Comprehension	16	R				x
Technical Data Interpretation	10	R				x

The chart which appears on the following pages was prepared to indicate, by AQE aptitude areas and score levels, those counterpart jobs in the civilian technology based on the Dictionary of Occupational Titles.

Relating the test scores to jobs with this chart is only one source of information to determine potential aptitude. Combining the aptitude with personal interest, suitability, experience, and other data provides a pattern for counseling students into vocations where they are most likely to succeed. It is important to remember that many civilian and military specialties require some degree of formal training before the individual is qualified to perform in his field of endeavor.

CHART 1. AQE APTITUDE AREA AND LEVEL RELATED TO DOT JOB LISTINGS[a]

AF Career Field	Related Civilian Jobs
ELECTRONICS	
Minimum Score of 80	
RADIO-RADAR SYSTEMS	Communications Engineer Electronics Engineer Radar Equipment Foreman Radio Mechanic II Radio Repairman
ARMAMENT SYSTEMS MAINT	Radar Maintenance Television Maint Precision Instru Maint
NUCLEAR WEAPONS	Elect Equip Tester Elect Instru Rprmn
TRAINING DEVICES	Instructor, Link Tnr Radio Mechanic II Instrument Man IV
MISSILE ELECTRONIC MAINT	*(Training and experience received in the Guided Missile Systems Career Field provide personnel with knowledge for certain civilian occupations. The degree of advancement and proficiency achieved in a particular career field will determine the extent to which qualified for related civilian field.)*
Minimum Score of 60	
INTRICATE EQUIP MAINT	Business Mach Insp Camera Rprmn Hosp & Surg Equip Svcmn Stat Mach Svcmn Tabulating Equip Mech
ACFT & MSL ELECT RPRMN INSTRU RPRMN	Electrician, Airplane Foreman, Acft Mfg Hydraulic Tester Oxygen System Tester
GENERAL	
Minimum Score of 80	
INTELLIGENCE	Draftsman, Topographical Investigator VI Interpreter Translator Coding Clerk Radio-Message Router Radio Operator Cryptanalyst Cryptographer Photo Interpreter
WEATHER	Meteorologist Weather Forecaster Weather Observer

AF Career Field	Related Civilian Jobs
GENERAL *(Cont.)*	
Minimum Score of 60	
AIR TRAFFIC CONTROL & WARNING	Airport Control Opr Instru Landing Tech Air Route Traffic Controller Aircraft Log Clerk
INFORMATION SVCS	Reporter (Print & Pub) Copy Reader (Print & Pub) Public Relations II Historian Editor, News (Print & Pub) Radio News Copyman Script Writer News Analyst Continuity Writer
EDUCATION & TNG	Teacher, Grade or Grammar School Registrar, Education Vocational Training Teacher Film Library Clerk Drillmaster
DENTAL	Dental Hygienist Dental Mechanic
MEDICAL	Food & Dairy Inspector Laboratory Technician Nurse, Industrial Nurse, Male Orthopedic Technician Pharmacist Physical Therapist Physician's Assistant Sanitary Inspector Surgical Orderly X-Ray Technician I
Minimum Score of 40	
PHOTOGRAPHIC	Cameramen (Motion Picture) Dark Room Man Film Editor (Motion Picture) Photographer, Aerial Photographer, Commercial Photographer, Portrait Photographer, Finisher Sound Mixer
FOOD SERVICE	Beef Cutter II Bench Hand II Chef III Cook, Mess Cook, Pastry Meat Cutter Oven man Pastry Chef II Pie Maker Roundsman Steward III

[a]The material for this chart was assembled for use by high school guidance counselors. The chart was prepared by personnel of the 3507th Recruiting Group, USAF Recruiting Service, Lincoln AFB, Nebraska, and is included here with their permission.

CHART 1. *(Continued)*

AF Career Field	Related Civilian Jobs
GENERAL *(Cont.)*	
Minimum Score of 40 *(Cont.)*	
AIR CREW PROTECTION	Guide, Hunting & Fishing Forest Ranger
PRINTING	Compositor I Darkroom Man Linotype Operator Linographic Pressman Offset Pressman Photoengraver Photolithographer Photostat Operator
AIR POLICE	Guard Guard, Penitentiary Motorcycle Patrolman Police Inspector Police Officer Supt of Police Watchman I Detective Investigator
PHOTOMAPPING	Map Draftsman Mapmaker Cartographer Compass Man
MECHANICAL	
Minimum Score of 60	
ACFT & MISSILE ENGINE MECHANIC	Aerial Engineer Aircraft Engine Mech Aircraft Mechanic Airplane Inspector I & II Engine Tester Engineman II Aeronautical Engineer
MUNITIONS SPECIALIST	Foreman (Explosives) Ammunition Foreman Detonator Assembler Munitions Foreman Powderman, Ammo Pyrotechnic Mixer
MUNITIONS & WEAPONS MAINT	Aircraft Armament Mech Armament Mechanic Armorer Gun and Turret Worker Gunsmith
Minimum Score of 50	
GAS GENERATING PLANT OPER	Gas Plant Operator Substation Operator
UTILITIES	Purification Plant Opr Foreman, Water works Sewer and Waterworks Fore Water Filterer Plumber, Foreman Steamfitter Foreman Air Conditioning Mech II Electrician

AF Career Field	Related Civilian Jobs
MECHANICAL *(Cont.)*	
Minimum Score of 50 *(Cont.)*	
UTILITIES *(Cont.)*	Plumber, Repair Plumber Boilerhouse Inspector Furnace Tender Gas Appliance Svcmn Production Controller
LIQUID FUEL SYSTEMS MAINT	Manager, Bulk Plant Foreman II, Petro Industry Tester, Petroleum
Minimum Score of 40	
FIRE PROTECTION	Fire Chief Fire Inspector or Marshal Fire Extinguisher Rprman Fire Equipment Man Fireman III
WIRE MAINT	Cable Splicer Central Office Repair Lineman, Senior Telephone Inspector Teletype Repairman Manual Equip Rpr, Central Off
OFFICE MACHINE REPAIRMAN	Office Machine Svcmn Statistical Mach Man Business Mach Insp
ACFT & MISSILE MAINT	Airplane Mech Carburetor Man Hydraulic Tester Foreman (Acft Mfg)
MOTORIZED & MISC EQUIP MAINT	Automobile Repairman Truck Mechanic Tractor Mechanic Motor Analyst Maintenance Mech II Automobile Accessories Installer Automotive Test Engine Mech
METAL WORKING	Machinist Plater I Sheet Metal Worker Acft Sheet Metal Worker III Toolmaker Welder, Aceteleyne Welding Specialist
METALS PROCESSING SPECIALIST	Boilermaker Blacksmith Welder, Combination
PARACHUTE AND FABRIC	Parachute Inspector Shroud Web Inspector Parachute Repairman Parachute Folder or Packer Foreman, Leather Mfg Tire Inspector II Tire Classifier Fabric Worker Doper I, Acft Mfg Tire Repairman & Vulcanizer Buffer, Rubber Tire & Tube

CHART 1. *(Continued)*

AF Career Field	Related Civilian Jobs
MECHANICAL *(Cont.)*	
Minimum Score of 40 *(Cont.)*	
AIR FREIGHT SPEC	Cargo Handler
MOTOR TRANSPORTATION	Dispatcher, Vehicle Shipping Clerk Traffic Rate Clerk Trailer Truck Driver Ticket Agent Greaser or Oiler Taxi Driver or Chauffeur Yardmaster Conductor, Yard
FUEL SPECIALIST	Pumpman Oil Pumper or Checker Tester, Petroleum
CONSTRUCTION	Blaster III Bricklayer II Cabinet Maker I Carpenter, House I Cement Finisher II Painter, Spray I Power Shovel Operator
ADMINISTRATIVE	
Minimum Score of 80	
ACCOUNTING & FINANCE	Auditor Accounting, Cost Accounting, General Bookkeeper II Payroll Clerk Accounting Clerk Paymaster Bank Cashier Manager, Credit & Collections Budget Clerk Public Accountant
DATA PROCESSING MACHINE OPERATOR	Supervisor, Machine Records Key Punch Operator Sorting Machine Opr Verifier Operator Tabulating Machine Opr
STATISTICAL SVC	Statistician Statistical Clerk Statistical Research Asst Calculating Machine Opr
Minimum Score of 60	
CHAPLAIN SVCS	Chief Clerk Clerical Technician Organist Teacher, Bible School
PERSONNEL	Receptionist Employment Clerk Personnel Clerk Vocational Adviser Job Analyst Employment Interviewer Manager, Employment

AF Career Field	Related Civilian Jobs
ADMINISTRATIVE *(Cont.)*	
Minimum Score of 60 *(Cont.)*	
PROCUREMENT	Billing Clerk Expediter Purchasing Agent Procurement Clerk
RADIO OPR (AIR & GROUND)	Radio Operator, Flight Radio Operator, App Radio News Copyman Radio Operator
NON-MORSE OPR	Radio Operator, Flight Radio Operator, App Radio Message Router Radio Dispatcher
Minimum Score of 40	
COMMUNICATIONS OPERATION	Telephone Supervisor Teletype Operator Central Office Operator
AIR TRANSPORTATION	Steward, Int'l Airlines Foreman, Air Transportation Ticket Agent Passenger Agent
SUPPLY	Inventory Clerk Stock Clerk Stock Control Clerk Manager, District Warehouse Stock Parts Inspector Shipping Clerk Receiving Clerk II Marker Checker Manager Retail Food Commissary Man
ADMINISTRATIVE	Law Clerk Claim Adjuster Court Clerk Tax Collector Secretary Stenographer Stenotype Operator Court Reporter Mail Sorter Insured & Registered Mail Clerk Post Office Clerk
SPECIAL SERVICES	Manager, Recreational Estblmnt Group Worker (Community Recreation Organizer) Director, Playground Athletic Coach Athletic Trainer Instructor, Physical Masseur Director, Stage Actor Grounds Keeper, Sports Social Welfare Administrator

Some Normative Comparisons

A question might be raised about the meaning of the Airman Qualifying Examination scores from the normative point of view. Information on regional differences has been reported (Gordon, 1955; McReynolds & Nichols, 1953; Thompson, 1958b) and some comparisons with Project TALENT norms are available (Dailey *et al.*, 1962).

First, with reference to geographical area differences, three separate studies, two on the Airman Classification Battery Form AC-1B and one with Form AC-2A, indicated that trainees from Army Areas VI (Far West), I (Northeast), and V (Middle West) were generally superior in mean test score; Army Areas III (Southeast) and IV (Southwest) generally had somewhat lower mean scores on the aptitude tests (see Figure 1 for location of Army Areas). The far West and Middle West were superior to other regions on the tests of mechanical experience; the Northeast was particularly high on verbal tests and on the highly speeded numerical test.

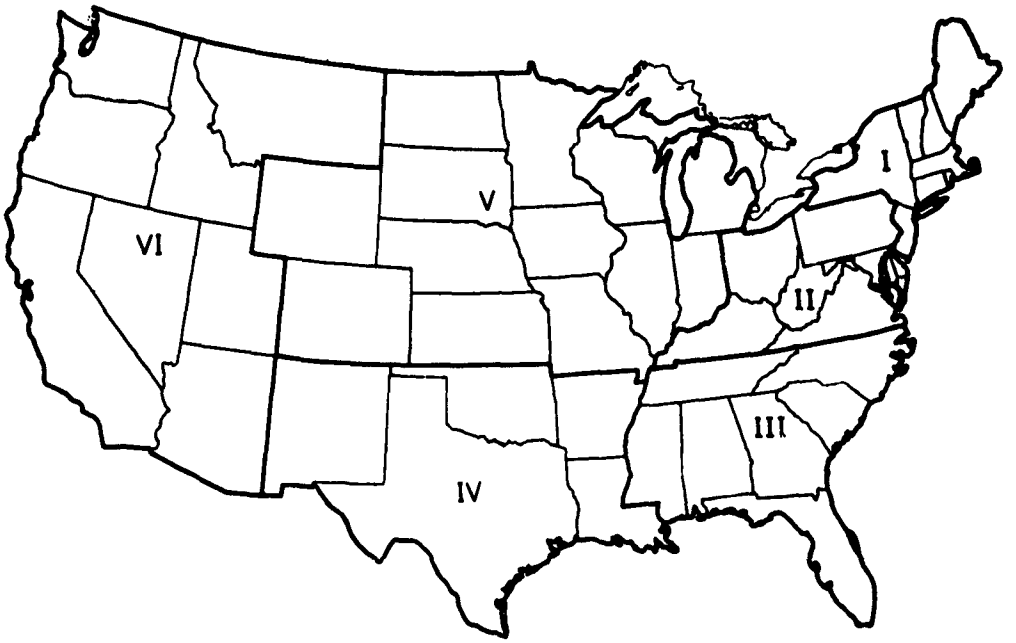


Fig. 1. Army enlistment areas of the United States.

In a somewhat different normative comparison, the United States Employment Service General Aptitude Test Battery was administered to a group of basic airmen in 1958 and the results were compared with a similar administration in 1949 (McReynolds, 1959). These data, along with the USES normative sample, are shown in Table 5, and they give some indication of the relative position of the Air Force enlisted personnel inputs for those time periods with reference to the level of the general working population of the United States. On the separate tests of the battery, means for the 1958 group of basic airmen are close to those of the USES normative sample and the 1949 groups are nearly as close. One area where the airmen are noticeably lower is on Test 8, a paper-and-pencil test of Manual Dexterity. However, none of the airman classification tests attempt to measure this factor, and there is some recent research which suggests that paper-and-pencil tests do not and cannot measure adequately a manual or finger dexterity ability (Fleishman & Ellison, 1962).

TABLE 5. Distribution Statistics for Airmen and USES Samples on the General Aptitude Test Battery

GATB Test Number	Form B - 1001, 1949				Form B - 1002, 1958					GATB Aptitude[a]			
	Airmen (N = 1096)		USES Sample (N = 4000)		Airmen (N = 2649)		USES Sample (N = 4000)			Airmen (N = 1096)		(N = 2649)	
	M	SD	M	SD	M	SD	M	SD		M	SD	M	SD
1[b]	62.4	15.7	70.7	22.1	41.0	11.3	43.7	16.0	G	106.7	14.8	102.3	13.9
2	27.5	5.7	28.1	8.1	22.8	4.6	23.1	6.7	V	95.1	14.2	95.9	12.5
3	23.6	6.2	19.0	7.0	20.2	5.3	16.8	6.5	N	104.1	15.5	99.7	14.4
4	18.6	6.6	21.5	9.4	17.9	6.2	19.8	10.0	S	116.2	17.9	110.3	16.5
5[c]	22.5	4.6	21.8	6.1	28.1	6.1	29.1	6.6	P	104.9	15.6	99.4	17.7
6	9.8	3.0	9.9	3.8	11.7	2.9	11.4	3.5	Q	91.4	15.6	96.5	14.2
7	27.5	6.9	27.0	8.1	25.3	5.8	23.9	7.0	K	88.4	17.1	93.0	17.0
8	63.4	9.0	69.5	10.3	65.8	8.8	69.5	10.3					

[a] USES Mean is 100 and SD is 20.

[b] The format of booklet-answer sheet was changed between Form B-1001 and Form B-1002.

[c] Form B-1002 has 9 more items than Form B-1001.

In a second normative study (Humphreys, 1960, 1962) accomplished through extensive cooperation with the Aviation High School, New York City, the Airman Classification Battery Form AG2A was administered to 1600 students in the school at midterm of the 1958-59 academic year. The following year at approximately the same point in time the same battery was readministered. The Aviation High School offers two curricula: a pre-engineering technical curriculum and a terminal aviation mechanic course. A major purpose of the experimental testing was to evaluate the stability of the Air Force tests in terms of average performance over time as demonstrated by resistance to special training or test practice effects. Table 6 presents some of the data obtained for the retest group and three control groups who were tested only once. There are at least three items of interest in the mean aptitude indexes.

One, the control groups tend to test somewhat lower than the retest group, perhaps because the controls contain large numbers of drop-outs from the school. (Control groups were formed *ex post facto* from test data available on students who appeared for only one administration of the battery). Two, the mean growth in aptitude indexes is somewhat greater for the controls than for

TABLE 6. Distribution Statistics on Airman Classification Battery for High School Students

Aviation HS Samples	Airman Classification Battery Aptitude Indexes							
	Mechanical		Administrative		General		Electronics	
	M	SD	M	SD	M	SD	M	SD
812 students retested after 1-year interval								
Test	46.5	19.3	35.0	17.7	40.6	18.0	41.8	18.1
Retest	63.1	18.1	41.5	19.4	52.8	20.6	53.0	19.4
Control group tested once only								
223 Sophomores	37.0	19.2	30.3	16.8	32.3	16.5	32.1	17.6
210 Juniors	48.1	18.6	35.8	17.0	38.4	17.7	39.9	17.5
322 Seniors	60.6	16.7	37.9	19.2	46.3	21.0	51.9	19.6

the rete st groups. The Mechanical and the Electronics indexes in particular show a considerable effec t of the special training. Third, these groups tend to score below the mean of Air Force enlistees entering the service in 1958-59, particularly on the Administrative Aptitude Index. Because of selective factors operating with respect to the kinds of students choosing the curricula of this high school, the effects on aptitude indexes are in the expected direction.

Still another set of data comparing Air Force enlistees with civilian populations has recently been obtained. Table 7 shows equivalents on the AQE percentile scale to four composite score percentiles derived from weighted sets of tests from the Project TALENT data. These norms show how a group of Air Force enlistees stand on certain TALENT tests as compared with 12th grade boys and 18-year-old boys in the general population. More detailed information on the d e rivation of these data is contained in a separate report (Dailey *et al.*, 1962).

TABLE 7. AQE Scores Related to TALENT Composites

AQE Percentile	TALENT Composites							
	Mechanical		Administrative		General		Electronics	
	12th Gr	18 Yr	12th Gr	18 Yr	12th Gr	18 Yr	12th Gr	18 Yr
95	91	94	71	79	88	92	79	85
90	84	89	60	71	80	86	76	82
85	75	83	50	62	73	82	66	75
80	69	77	44	56	67	76	58	69
75	64	73	39	52	61	71	50	61
70	59	69	29	43	49	61	44	56
65	46	57	25	38	43	55	41	53
60	37	50	20	32	36	48	34	47
55	30	42	15	26	24	37	28	40
50	27	39	12	21	19	32	23	36
45	22	34	9	17	14	26	18	30
40	18	28	5	10	12	23	14	25
35	14	24	4	8	9	19	11	21
30	12	20	3	5	4	12	9	18
25	9	15	1	3	2	7	5	12
20	4	9	--	2	1	3	4	11
15	1	4	--	1	--	1	1	5
10	--	2	--	--	--	--	--	1
05	--	--	--	--	--	--	--	--
01	--	--	--	--	--	--	--	--

Aptitude Inputs to the Air Force[2]

The aptitude level of basic airmen over time, particularly since the USAF Recruiting Service has in recent years made an intensive effort to obtain the maximum quality consistent with the numbers to be enlisted, shows an interesting trend. Since 1948 the Air Force has used a program of aptitude testing for enlisted accessions as one factor in making job and training assignments within the manpower spaces available. In the 13-year period through 1961 there have been two basic procedures used in determining which applicants would be enlisted.

[2] This section is based on an earlier report by Lecznar (1962).

Initially, with the implementation of the Department of Defense Armed Forces Qualification Test, applicants for Air Force enlistment were screened first on the Enlistment Screening Test at the recruiting level followed by administration of the AFQT at Recruiting Main Stations or, later, in what was called an Armed Forces Examing Station. Assuming the applicant then met the physical requirements, he was enlisted. Aptitude testing for classification and assignment purposes was part of the program during basic military training. Within this general set of procedures, details varied from time to time based on the needs of the services. For example, AFQT minimum cutting scores were varied and there has been a qualitative distribution of manpower across the services based on AFQT scores.

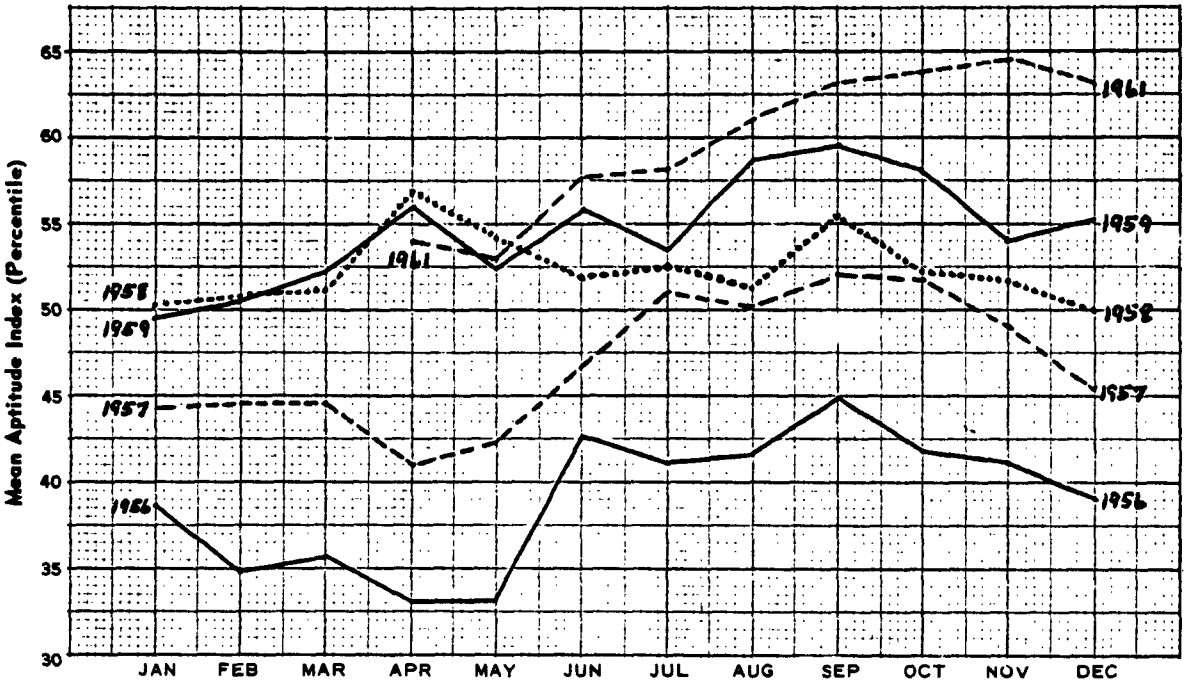
Beginning in April 1958 the Air Force instituted a program of selective enlistment. Applicants who had qualified on the AFQT were next required to meet certain minimum requirements on the Airman Qualifying Examination (AQE). In effect, as the program evolved, the applicant was selected and actually classified before he was accepted for enlistment. In a subsequent variation, administration of AQE became the first hurdle imposed on an applicant; subject to qualification for at least one of several job-aptitude quota groups, the individual then had to meet the minimum AFQT score and be physically qualified in order to be enlisted. Again there have been variations in the details of the selective enlistment program from time to time such as changes in AQE aptitude minimums, use of educational requirements as secondary screens, and varying administrative procedures, all intended to maximize quality within manpower procurement objectives.

In the Air Force, assessment of aptitudes during this period has been accomplished through two instruments, the Airman Classification Battery AC-2A and the Airman Qualifying Examination. The AC-2A was administered at the basic military training center from January 1956 through August 1959, but the aptitude scores were used for classification and assignment purposes only from January 1956 until April 1958. The Airman Qualifying Examination Form D became a selective recruiting instrument in the hands of the USAF Recruiting Service on 1 April 1958 and was used until 1 November 1960 when AQE Form F became the enlistment aptitude qualification test, followed by AQE Form 62 on 1 October 1962. The AC-2A had been standardized and normed to the World War II mobilization population with the AFQT as a common base. AQE was normed on an equipercentile procedure to the AC-2A, and Forms D and F of AQE were standardized so as to be equivalent forms.

Figure 2 shows the mean General Aptitude Index by month for the years 1956 through 1961, except 1960 for which means have not been summarized. The values shown are for male non-prior-service enlistees. There are several points of interest in this chart.

There has been a progressive increase in the quality of Air Force enlisted accessions as measured by this aptitude index. Because of the many factors which might cause such an increase, it is difficult to ascribe the change in aptitude level to any particular event. There have been some procedural policies that impact here; for example, the selective recruiting program has tended to defer enlistment of applicants who did not achieve the 40th percentile on at least one of the four aptitude indexes in the Airman Qualifying Examination. But at the same time, it might be suggested that Sputnik in October 1957 caused a general upgrading of the quality of education; or perhaps more general use of aptitude tests with emphasis on counseling and guidance may be a contributing factor to the upward trend.

The relatively low quality of the input in 1956, where the mean General Aptitude Index ranged from a low of 33 to a high of only 45 (the theoretical mean of the World War II mobilization population was 47.5), can probably best be accounted for in the Department of Defense directive on allocation of manpower. In that year, the Air Force enlisted considerably greater numbers of airmen in the Category IV level on the Armed Forces Qualification Test in proportion to the total input; this was done to even out the percentage of Category IV personnel



across the services. It has previously been pointed out that quality of Air Force inputs varies as a function of the screening and allocation policies. The mean aptitude level of the 1956 group tends to confirm these findings.

Changes in mean AI by month of the year follow a rather consistent pattern over the years. April and May represent the low point in aptitude level, with June, July, August, and September showing a gradual increase to a high, followed by a gradual decrease in October, November, and December, and a leveling off in January, February, and March. This trend probably reflects school schedules and the traditional summer months when schools close. As September approaches, the high school graduate who has no plans for college reaches the decision to discharge his military obligation by voluntary enlistment.

There are variations that appear within the monthly cycles and some of these points can be associated with known events. One of these, April 1958, marked the start of the selective-pre-enlistment program with specific monthly quotas, by aptitude levels, to be filled; there was an associated establishment of the 40th percentile on at least one aptitude index as a requirement for eligibility over and above qualifying on AFQT at the 21st percentile. The continuation of high quality in October, November, and even December 1961 was probably a function of two factors—the Berlin crisis which led to call-up of reserves and increased draft quotas as an external event, and implementation of a procedure within the Recruiting Service to "take off the top" of the available applicants to meet monthly objectives rather than selecting on a "mine run" basis. There is no readily apparent event that might be associated with the steep rise in mean General AI in August 1959. The data in Table 8 on the number of high school graduates among Air Force enlistees show some interesting trends. First, the percentage of high school graduates in the input by month and year of enlistment follows very closely the pattern in Figure 2. From a moderate level in January and February, there is a decrease in March to a low in April and May. June shows a tremendous rise to a high point; July and August drop somewhat, with a slight upswing in September. There follows a progressive decrease through October, November, and December. This is, of course, what would be expected to happen to

the mean General Aptitude Index; its trend should be consistent with that of the percentage of high school graduates in the enlistment group.

Of somewhat greater importance is the trend in percentage of high school graduates in the input over the years. In 1951 to 1953, this value was around 53 percent; in 1954 it dropped to 50 percent and has shown a general rise since.[9] In 1958, the year when selective recruiting started, 72 percent of the enlistees were high school graduates; in 1961, this rate was up to 77 percent, and for 1962 it climbed to 83 percent. The trend probably has its basis in two factors. First, the impact of selective recruiting which attempts to maximize quality consistent with manpower objectives; and second, efforts on the part of the USAF Recruiting Service to encourage completion of high school before enlistment. The latter procedure stems, in part, from data which suggest that the high school graduate is less likely to be released from the service for reason of unsuitability (Flyer, 1959).

TABLE 8. Percentage of High School Graduates in Air Force Enlistments

(Data limited to non-prior-service males at Lackland AFB)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1952 Input	13708	12274	8303	5270	4576	6775	7184	7503	5242	4024	2959	3229	81047
% HSG	57.3	58.8	56.3	50.6	41.6	60.1	52.3	46.8	53.6	50.7	49.2	44.9	53.6
1953 Input	3702	6156	5984	4266	1686	851	1917	1835	1605	3111	4062	4747	39922
% HSG	54.0	56.1	56.9	53.2	51.6	64.0	59.7	62.0	61.2	54.4	46.6	37.9	53.1
1954 Input	--	7755	--	4908	5462	7788	8596	8160	7531	9289	4641	3627	67757
% HSG	--	38.4	--	38.1	44.4	70.7	62.1	50.8	47.0	50.8	43.4	37.2	50.0
1955 Input	7521	8988	4082	6284	3873	6375	4904	4420	4806	4360	4339	2355	62307
% HSG	51.0	48.5	35.8	22.7	31.3	64.6	75.6	79.0	71.2	65.4	54.1	46.3	53.5
1956 Input	--	7305	5252	4212	--	9360	7447	8913	12945	9570	8267	5094	78365
% HSG	--	57.6	35.2	31.3	--	76.0	66.8	60.7	63.4	57.9	52.9	47.4	57.9
1957 Input	10938	7749	7248	--	6223	8266	7720	7759	--	5064	--	--	60967
% HSG	52.0	54.7	50.6	--	49.9	77.9	79.1	74.9	--	71.7	--	--	63.5
1958 Input	4192	5966	3441	3102	3538	5079	6602	6614	6095	6037	5594	3087	59347
% HSG	60.4	61.5	61.8	67.4	61.8	74.3	80.4	79.8	80.6	76.3	73.3	66.9	71.9
1959 Input	5425	5157	5271	2082	3912	6159	7226	7423	7327	7069	7031	4501	68583
% HSG	65.5	68.2	66.6	49.5	66.0	79.2	80.5	80.2	80.5	76.3	66.0	62.6	72.3
1960 Input	6940	7323	6603	4703	5404	11666	9518	11444	12625	9417	7630	5174	98447
% HSG	66.5	61.4	56.8	50.6	63.2	82.9	82.2	76.0	76.6	70.1	66.8	60.2	70.4
1961 Input	11720	8742	9467	6903	7317	10751	11054	11276	10474	9618	8977	5264	111563
% HSG	66.4	66.0	60.6	59.1	64.1	84.8	86.8	85.3	87.6	86.5	82.0	97.9	77.4
1962 Input	10314	9207	8114	7902	6135	11145	8158	10789	10984	8707	6450	4242	102147
% HSG	93.4	93.2	72.9	68.5	75.8	88.4	87.0	84.4	85.2	81.8	75.5	71.5	82.8

SECTION 3. SOME TECHNICAL ASPECTS OF AIR FORCE CLASSIFICATION TESTS

Prior to 1947, assignment of enlisted personnel in the services was based almost solely upon the single score achieved from the Army General Classification Test (AGCT). Classification based on a single general score such as AGCT is as wasteful as the use of a general purpose fertilizer on all types of soil without regard for an analysis of the nutritional elements available in each type. For any given soil type, many of the minerals in the fertilizer are wasted because they may already be available in sufficient quantity. Similarly, when personnel are selected for a specific training course because of high AGCT score (high average score on several different abilities), their high abilities on factors not particularly relevant to that course are wasted.

For example, assume a certain course has a minimum AGCT score of 110 for entrance, and that 30 percent of Air Force enlistees are qualified by AGCT score to enter the course. Since a specific aptitude index validated for that course would probably not be highly correlated with AGCT, some enlistees below AGCT 110 would qualify on the specific index and some above AGCT 110 would *not* qualify. Thus the individuals below AGCT 110 best qualified on the index could be substituted for those qualified on AGCT, but not on the index, with no reduction in the *over all* quality of students. As a consequence, use of specific indexes instead of a single general score results in economy of talented personnel. Low abilities on one index are compensated for by high abilities on another index, but on a general score these differences are not readily apparent or usable.

The Way Tests Are Used[3]

A basic reason for using tests to select men for training lies in the fact that it costs less to test a man than it does to attempt to train him and discover that he is untrainable. A testing program becomes more valuable as the pool of men from which trainees are to be selected becomes larger, so that smaller portions of the pool can be taken for training. The proportion of men selected from the pool is called the "selection ratio," as shown in Figure 3.

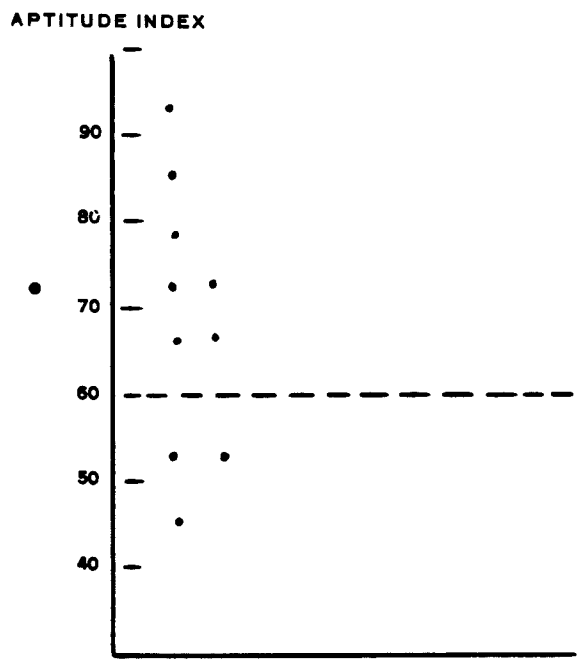


Fig. 3. **Selection ratio.** If the aptitude minimum is set at 60, 7 men are selected from the 10 available; the selection ratio is .7. If the aptitude minimum were set at 70, the selection ratio would be .5.

[3] This section is based on material from Brokaw & Holdrege (1960).

As the selection ratio becomes more favorable the use of a valid test reduces the cost of training in terms of cost per graduate. The operation of this factor can be observed in Figure 4. If measures of airman productivity, for example grades from technical school, are plotted on a chart against the aptitude indexes achieved if unselected airmen are sent to that school, it will be found that they fall in an oval area like that in the figure. If a certain technical school grade, shown by the broken horizontal line in the figure, is established as the passing mark, the area below the line indicates the proportion of examinees who will fail in the school.

Establishment of an aptitude minimum, say at 60 as shown by the vertical line in the figure, below which airmen are not admitted to training, eliminates numbers of trainees who would fail in the school, and therby saves training costs for them. Raising the aptitude minimum, as shown in Figure 5 by the parallel broken lines added to the right of the aptitude minimum alters the selection ratio so that the number of eliminees per graduate is reduced, and the cost of training is lowered still more.

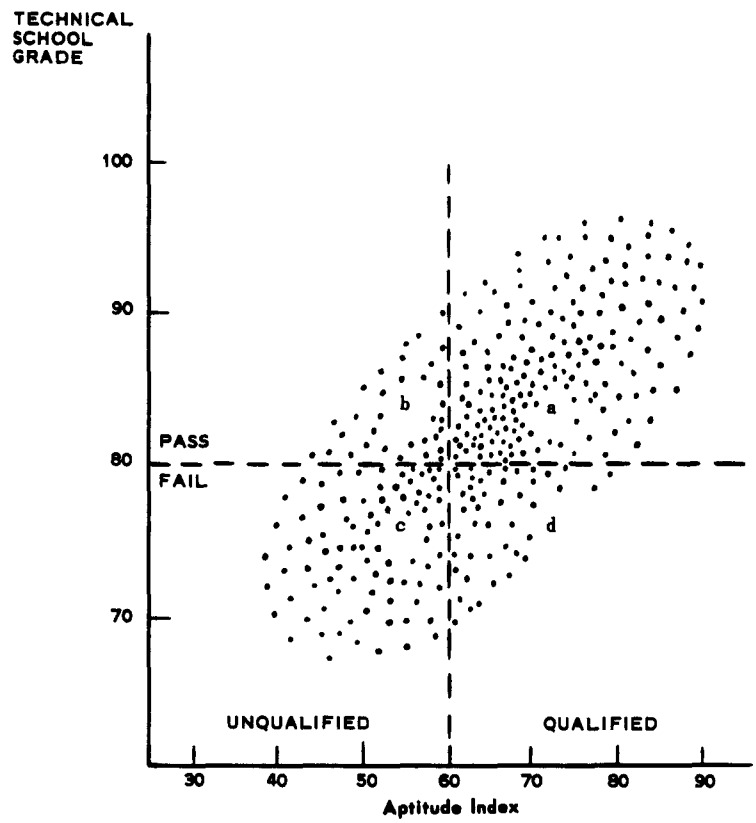


Fig. 4. **Relationship of technical school grade to aptitude index.** The figure shows the pattern of grades and aptitude indexes expected in a relatively unselected sample. The lines show the relationship between a recommended aptitude index and the passing mark in the school. The dots in area "a" represent airmen who are qualified on the aptitude index who would pass in school. Area "b" represents airmen who would not be admitted to training, but who would graduate if admitted. Area "c" includes men who would fail in training, who are barred from training by the aptitude minimum. Area "d" contains men who are admitted, but who fail in school. Note that the position of the aptitude minimum bears directly on the proportion of men admitted to school who pass; insofar as this represents a gain in the rate over the rate expected for an unselected population, economies are effected.

It is apparent that a number of airmen who would "pass" the school, are eliminated by the recommended aptitude minimum. These potential graduates can be obtained for training by lowering the aptitude minimum, but at a higher cost per graduate due to the increasing costs of the partial training received by eliminees.

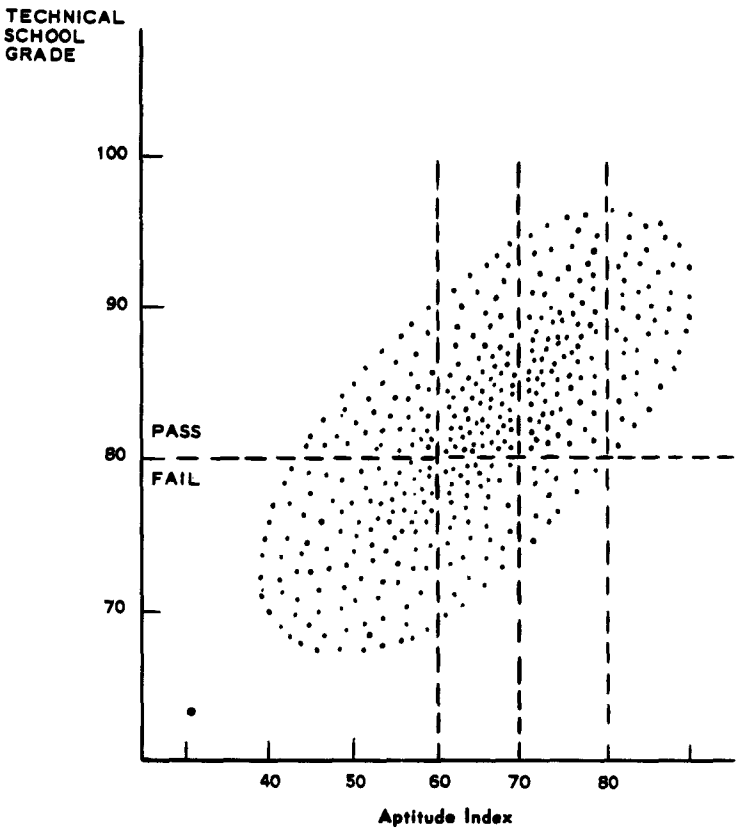


Fig. 5. **Effect of raising minimum aptitude index on selection ratio and on failure rate.** Note that raising the recommended minimum to the 80 level reduces the failure rate to 0, but also establishes a severe selection ratio.

If the pool of potential trainees is sufficiently large to permit placement of a severely high aptitude minimum, insuring a greater certainty of graduation for each man entering training, the number of men entered into training can be reduced closer to the number of men actually needed in Air Force jobs, and a maximum economy in training is realized.

Further inspection of Figures 4 and 5 will reveal that there is no information upon which an objective aptitude minimum can be established–there is no realistic level of aptitude above which all men "pass" and below which all men "fail." This could be true only with a school grade of perfect reliability and a test of perfect validity.

The establishment of a minimum must balance the size of the potential trainee pool against the number of men who must be trained. As the selection ratio is improved, and as the validity of the test is raised, economies in training will result.

This discussion assumes graduation of a trainee capable of meeting certain standards of competence. It is apparent that a decrease in the ability of trainees would require adjustments in training procedures to prevent an increased failure rate. These adjustments might take the form of maintaining the proportion of graduates by lengthening the training period, or by having larger numbers of students repeat the course.

These devices for maintaining the flow through a school in the face of a reduced capability on the part of trainees carry with them an increase in training costs. These costs can be direct, in the form of dollars for students who are trained for an increased length of time; and indirect, if graduates must be accepted who are less competent to assume the duties of Air Force jobs.

Scaling and Norms

As with any test or battery that is used to compare individuals, test scores need to be stated in some standard form. The early Air Force classification tests used a standard 9-point scale, called "stanines," developed during World War II. Both the subtest scores and the composites were expressed in this form. Beginning with Form AC-2A of the Airman Classification Battery and Form D of the Airman Qualifying Examination, the composite scores or aptitude indexes have been expressed in terms of a modified percentile scale. This metric uses only 20 points: 01, 05, 10, 15 . . . 85, 90, 95.

Forms D and F of the Airman Qualifying Examination were normed by the equipercentile method to the Airman Classification Battery AC-2A. The standardization samples tested on AQE during its development process had previously taken AC-2A. Since the four composite scores of AQE had counterparts in AC-2A it was possible to make each of these distributions the same in shape and dispersion as the distributions of the composite scores in AC-2A for the sample tested. Thus AQE aptitude indexes could be treated as having the same meaning as the AC-2A indexes.

In turn, the AC-2A had been scaled to the World War II mobilization population through the use of the Army General Classification Test as a reference variable. Through a series of steps involving correlation of the AC-2A subtests with the AFQT and adjusting for truncation caused by selection on AFQT, the standardization sample for AC-2A was equated to the wartime population. As a result, AC-2A and AQE aptitude indexes have a common meaning as well as relationship to a "known" wartime population within fairly narrow error limits.

With the passage of time, there is increasing concern that the youth of the 1960's are different than the World War II mobilization population. Just as the base year for the cost of living index is changed periodically, it may be that the base group for norming of airman selection and classification tests needs to be revised. To that end, some of the data reported earlier on norms for Air Force personnel with respect to Project TALENT test composites will be considered for use as a new reference point for standardization of future Air Force tests.

Reliability and Validity

Specific values for the reliability and validity of the several composite scores have been computed at various times by standard statistical formulas. For the Airman Classification Battery Form AC-2A, reliability estimates are available for both the subtests and the composites or aptitude indexes (Brokaw & Burgess, 1957). These are presented in Table 9. The reliabilities for the aptitude indexes of the Airman Qualifying Examination, Forms D, E, and F are contained in Table 10. The values compare favorably with those reported for commercial aptitude test batteries. Individual test reliabilities for AQE have not been estimated, since subtest scores are not used separately for any purpose.

TABLE 9. **Reliability Estimates for Test Variables of Airman Classification Battery AC-2A[a]**

(Samples: Various numbers of basic airmen)

Variable	Type of Reliability Estimate					
		Split-Half[c]		Test-Retest	Alternate Form	
	r_{tt}[b] (N = 2202)	r_{11} (N = 500)	r_{11}	r_{tt} (N = 277)	r_{tt} (N = 2202)	
Aptitude Index						
Mechanical	.91					
Administrative	.89					
Radio Operator	.87					
General	.87					
Electronics	.93					
Biographical Inventory						
Mechanical Key				.76		
Administrative Key				.83		
Electronics Key				.70		
Arithmetic Reasoning		.75	.86		.75	
Verbal Test		.85	.92		.81	
Mechanical Test		.77	.87			
Tool Functions					.74	
Figure Recognition		.71	.83			
Clerical Matching					.87	
Numerical Operations					.80	
Technical Information		.76	.87			
Pattern Analysis		.78	.88			
Air Force Aural Code I		.81	.90			
Air Force Aural Code II		.92	.96		.74	

[a] From Tables 5 and 6, Brokaw & Burgess (1957).
[b] Estimated by a correlation of sums formula (Jackson & Ferguson, 1941).
[c] Corrected by Spearman-Brown prophecy formula for full test length.

TABLE 10. **Reliability Estimates for Aptitude Indexes of Airman Qualifying Examination**

(Samples: Various numbers of basic airmen)

Aptitude Index		Correlation of Form D with AC-2A				Correlation of Form E with AC-2A			Form F Test-Retest
	Size of Sample:	1177	320	1083	506	2428	320	371	681
Mechanical		.80	.81	.81	.83	.79	.80	.82	.83
Administrative		.76	.74	.78	.75	.74	.74	.80	.88
General		.81	.82	.81	.80	..78	.82	.84	.81
Electronic		.83	.85	.83	.84	.82	.85	.83	.82

The validity of the Air Force classification batteries is continually being determined by follow-up of students through technical training courses. The Airman Classification Battery in its first form, AC-1A, was recommended for use only after its predictive efficiency had been determined. Forms AC-1B and AC-2A of this battery were also checked against criteria of technical school grades across a wide variety of specialties with quite satisfactory results. Summaries of these data are listed in the references (Brokaw, 1959a, 1959b, 1959c; Gragg & Gordon, 1951; Thompson, 1958c). For the Airman Qualifying Examination, extensive validity data have been gathered for the Form F aptitude indexes on a number of technical training courses. The coefficients in Tables 11 through 14 are based on male airmen graduating from technical schools during the calendar year 1961. Both the raw coefficient and the one corrected for the restriction in range are at acceptably high values. The restriction resulted from selection for entry to the course at a specified minimum aptitude level (note the obtained standard deviation for the aptitude index as compared with the theoretical standard deviation of 28.8 for the percentile scale and one of approximately 23.00 obtained for all examinees tested in 1961). As a matter of fact, the efficiency with which each index predicts the training success in those schools for which it was designated as the selector index is at generally acceptable level.

TABLE 11. Validity of AQE-F Mechanical AI for Mechanical Training Courses

Course Number and Title	N	Mechanical AI		Final School Grade		Validity	
		Mean	SD	Mean	SD	r	r_c
42132-1 Acft & Missile Pneudraulic Rprmn	202	73.4	11.2	85.3	2.8	.42	.68
42231 Mechanical Access & Eqpmt Rprmn	164	71.7	11.1	85.3	2.7	.40	.67
43131A Acft Mechanic, Recip Eng Aircraft	770	59.3	13.7	85.8	2.9	.47	.66
43230-1 Jet Engine Mechanic	350	62.4	13.7	85.3	2.9	.47	.66
43231 Reciprocating Engine Mechanic	502	60.9	13.4	85.6	2.9	.40	.60
43330-5 Missile Mechanic	125	89.4	8.2	86.7	2.5	.31	.68
46230 Weapons Mechanic	253	82.2	7.9	87.6	3.0	.32	.70
47131 Automotive Repairman	233	73.3	10.3	85.2	2.4	.31	.58
53430 Airframe Repairman	198	68.7	10.9	86.9	2.6	.28	.53
54330 Electrical Power Production Specl	539	61.6	9.0	85.9	2.5	.39	.73
57130 Fire Protection Specialist	617	58.6	9.4	86.4	2.6	.28	.58

TABLE 12. Validity of AQE-F Administrative AI for Administrative Training Courses

	Course Number and Title	N	Administrative AI Mean	Administrative AI SD	Final School Grade Mean	Final School Grade SD	Validity r	Validity $_c$r
29130	Communication Center Specialist	740	67.9	13.1	85.5	2.6	.45	.66
64530	Inventory Management Specl	1041	60.0	13.3	85.8	3.4	.30	.48
64630	Organizational Supply Specl	1307	59.3	13.2	86.8	3.7	.50	.71
64730	Warehousing Specialist	433	59.5	13.3	86.9	3.2	.34	.53
67130	Acctng & Finance Specl	419	88.5	5.9	86.5	3.1	.20	.63
68530A	Data Processing Machine Opr	443	90.2	5.6	86.1	3.1	.08	.33
70230	Administrative Specialist	1350	64.6	13.2	85.4	3.2	.28	.46
73230	Personnel Specialist	622	79.4	8.5	86.0	3.1	.28	.63

TABLE 13. Validity of AQE-F General AI for General Training Courses

	Course Number and Title	N	General AI Mean	General AI SD	Final School Grade Mean	Final School Grade SD	Validity r	Validity $_c$r
25231	Weather Observer	214	88.9	5.6	85.4	2.5	.34	.83
27330A	Acft Control & Warning Opr (Manual)	282	67.3	5.6	86.3	2.6	.30	.80
27330B	Acft Control & Warning Opr (SAGE)	467	66.5	5.8	85.9	2.6	.22	.67
29230	Electronic Intercept Ops Specl	294	82.0	9.6	86.5	2.4	.33	.65
77130	Air Policeman	2233	55.8	11.4	84.9	3.3	.25	.46
90010	Medical Helper	1832	73.1	10.8	84.2	4.6	.35	.63
90010	Medical Helper Fundamentals	323	77.8	8.3	86.5	4.1	.25	.58

TABLE 14. Validity of AQE-F Electronics AI for Electronics Training Courses

	Course Number and Title	N	Electronics AI Mean	Electronics AI SD	Final School Grade Mean	Final School Grade SD	Validity r	Validity $_c$r
30130	Aircraft Radio Repairman	112	75.4	7.3	85.2	1.8	.31	.71
30432	Ground Comm Eqpmt Rprmn	127	75.4	7.5	85.7	2.5	.39	.79
42133	Acft Ground Eqpmt Rprmn	427	63.6	12.1	85.0	2.3	.40	.64
42230	Instrument Repairman	242	61.2	10.6	85.5	2.5	.38	.66
42330-1	Acft & Missile Electrical Rprmn	622	59.9	8.8	85.1	2.8	.40	.75
42333	Flt Control/Auto Pilot Sys Rprmn	352	60.7	8.6	85.4	2.8	.28	.62

SECTION 4. RESEARCH ON AIRMAN SELECTION AND CLASSIFICATION DEVICES

The development of tests for airman selection, classification, and proficiency measurement is a major part of the mission of the Personnel Research Laboratory. Equally important, however, is the role of the research program in the overall effort of the laboratory, because without research the future tests would be only replications of past versions. Keeping current with the technology and advancing the state-of-the-art are functions of the research in the total mission.

Aptitude Test Studies

Validation of the AQE aptitude indexes in predicting technical school grades is a continuing effort as a normal phase of the test building process. There is, in addition, a constant watch on these validities with respect to possible changes in combinations of subtests in the composites, or substitution of item types, to maintain or improve the validity of the composites. The possibility of changing the composite designated as the selector index for a given school is ever present, since the validity studies include analysis of all four indexes for each criterion.

Research on the aptitude test has been directed to three areas. First, there are those studies concerned with searching out new test variance to increase the predictive efficiency of an index. These studies take the form of extensive experimental test batteries administered to students selected for specific courses of training just prior to entry into that training. The purpose is twofold: one, it keeps the operationally used subtests in step with technological developments; second, it permits exploration of new ways of measuring some of the basic factors.

The second area is that of assessing the predictive efficiency of the aptitude indexes against job performance. Identifying the airman who can succeed in technical training is but half the task; it is equally important to predict with better than chance success those men who will also perform well in their job assignments after training.

The third area of research involves the mechanics of building and administering the test batteries. Such things as test length, number of different kinds of tests, ways of scoring and combining scores, all related to the amount of testing time available and the level of validity acceptable, are evaluated. For example, if a specific test not presently in the AQE is found to have some usable variance, should it be substituted in toto for an existing test or should shortened forms of both tests be used, and still stay within a set time limit. Research on the effects of training in the Aviation High School curriculum on test scores from test to retest provided some useful data on possible improvement of abilities through training. Other test-retest studies are in process for application to test norming and standardization and the results may well have implications for other testing programs as our school age population becomes exposed to more and more testing.

As the human being is a dynamic organism and as our technology evolves, so then must the building of future test forms incorporate the facts which become available only through an active research program.[8]

Measuring Personality

Test builders have done a good job in developing tests that measure learning aptitudes and educational achievement. The inventory of such tests and the capacity for producing new ones is limitless. Emphasis now is in an area where the record has not been good--measures of personality and character traits. We want to be able to identify the man who will work effectively in a team, who will stand up in a crisis, who has a capacity for leadership, who can deal imaginatively with Air Force problems

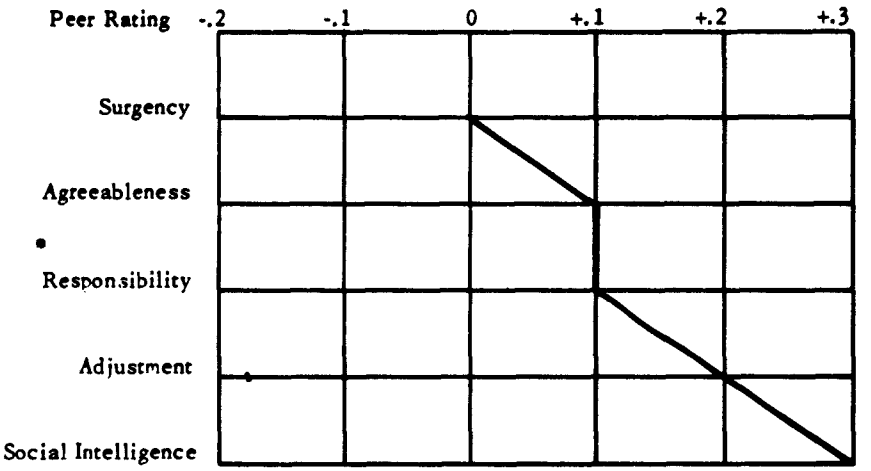


Fig. 6. **Correlations of personality ratings with efficiency ratings.**

A preliminary approach has been to get whole training classes to select from their fellows the ones that each of a set of adjectives applies to: goodnatured, assertive, talkative, and so on through a long list. Such ratings have established a group of stable personality factors. Figure 6 shows that some of them have a strong relationship with efficiency ratings. Now our task is to develop feasible paper-and-pencil tests of these factors by validating them against the highly reliable and stable peer ratings.

Identifying the Unsuitable Airman

A look at the records of the 100,000 men inducted in 1956 showed that over 10 percent were discharged as unsuitable before the end of the first 4-year tour of duty. The ***discharged*** group were different from the ***active-duty*** group on three counts. This is a logical picture. The younger boys haven't had time for college. The low aptitude people drop out of school early. This kind of information has led the Air Force to raise its education requirements, and to emphasize completion of high school as part of its recruiting effort.

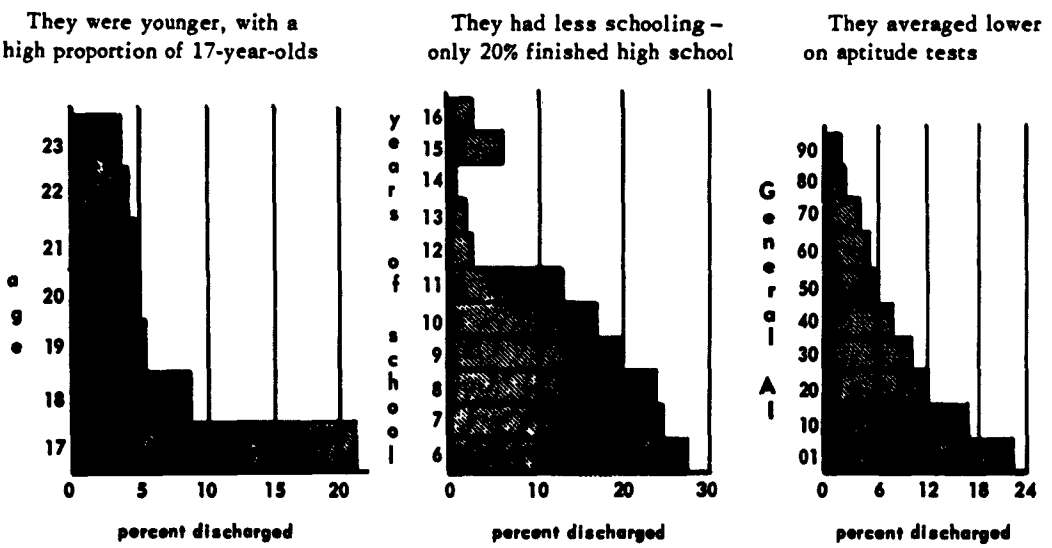


Fig. 7. **Characteristics of unsuitable airmen.**

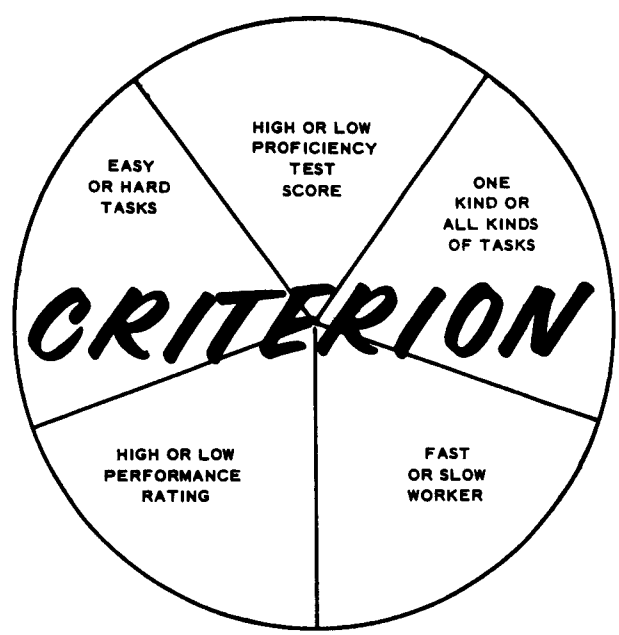
Identifying the Unreliable Airman

A few airmen prove incapable of adjusting to Air Force life. Others may be satisfactory in routine assignments, but can't be trusted in jobs requiring a high degree of personal responsibility. One approach to identifying these men is based on the simple premise that unreliable schoolboys are likely to be unreliable airmen. To test this assumption, we are questioning teachers and counselors of a large group of new airmen about their high school history. These men will be followed through their Air Force career to determine what elements in the high school history correlate with the military record.

Describing the Proficient Airman

Our selection and classification tests need to predict not only success in job training and in gaining job knowledge, but the full range of career effectiveness. Probably no single measure—peer ratings, supervisory ratings, written tests of knowledge, rate of increase in grade—will do the full job. Some combination of several measures may be the solution. Several new measures show promise as possible components.

Most Air Force jobs involve flexible work assignments. Let's assume that the most capable airman is assigned the most difficult tasks. With a suitable measure of task difficulty and a record of task assignments, a new proficiency scale emerges. Or perhaps the less competent airman is used on a small range of tasks while the best are assigned to any task in the job inventory. Or let's assume the proficient worker finishes a task in half the average time. Scores like these are entirely feasible since electronic computers can be programmed to produce them from information routinely gathered in task inventories.



Models for Data Analyses

Advances in statistical analysis support all of the test development activities. A generalized linear regression model has been developed and programmed for high-speed computing equipment which increases both the speed and scope of data analyses. Scientists respond to the increased analytical capability by designing broad gauge attacks. Instead of asking "Is variable X related to criterion y?" they ask "Which of these 50 variables, and in what combinations, are related to what extent to which of these criteria?" For answer, the scientist gets pages of print out like the sample in Table 15.

TABLE 15. **Machine Listing of a Sample Solution**

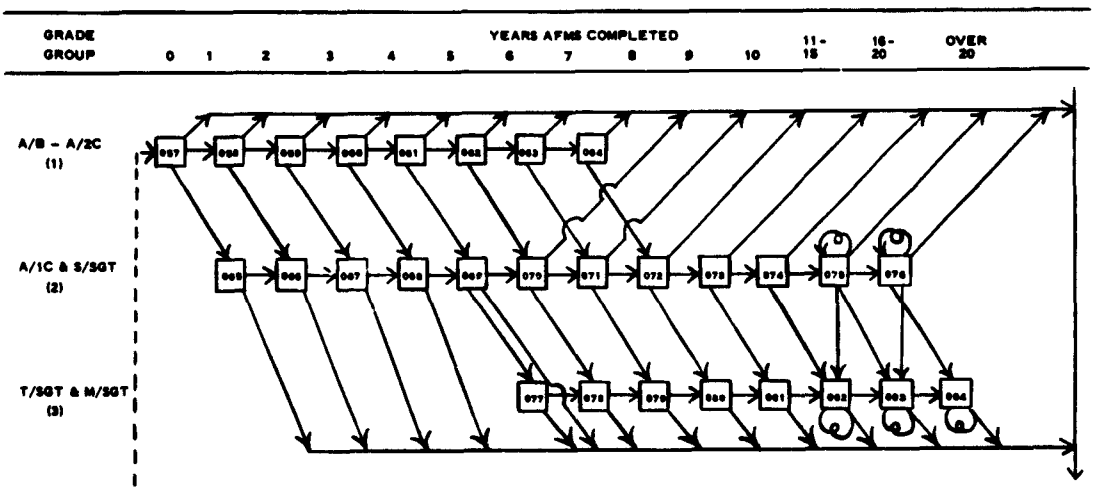
1	2	3	4	5	6	7	8	9
								CD#
VAR#	CORRECTION	MULT SQ	S	SD-SQ	IT CT	CRIT	ID	17
#VAR		FINAL MULT	S	SD-SQ	IT CT	CRIT	ID	18
VAR#	REG WTS	EQUAT ERROR	S	SD-SQ	IT CT	CRIT	ID	19
1	11 11111112	22 22222223	33 33333334	44 44444445	5556	77	7777	78
90	12 34567890	12 34567890	12 34567890	12 34567890	7890	12	3456	90
21	.40500000	.16402500	.16402500	.16402500	1	10	1	17
38	.35702465	.25186867	.29705238	.35034176	2	10	1	17
17	.31111610	.29240097	.41580540	.59129122	3	10	1	17
34	.22445974-	.31837423	.44193251	.61344268	4	10	1	17
24	.23405913	.34152882	.50906067	.75877274	5	10	1	17
5	.15721911	.35277426	.52273873	.77459103	6	10	1	17
28	.16804051	.36604990	.53003169	.76747348	7	10	1	17
40	.17145474	.37756216	.57761038	.88365249	8	10	1	17
33	.14796711-	.38691368	.59202238	.90586224	9	10	1	17
41	.12916219-	.39371111	.57175685	.83031913	10	10	1	17
18	.14008222	.40155011	.60878056	.92295769	11	10	1	17
50	.11546029	.40738558	.61548680	.92989659	12	10	1	17
21	.17057371-	.41524599	.54640645	.71899551	13	10	1	17
3	.12058948	.42374446	.55359356	.72323270	14	10	1	17
28	.09063392	.42859102	.55752709	.72525191	15	10	1	17
39	.09980081	.43343114	.58593040	.79208528	16	10	1	17
29	.10253939-	.43906079	.57338983	.74881634	17	10	1	17
43	.07680785-	.44248473	.58021037	.76080382	18	10	1	17
26	.08205139-	.44564986	.55567393	.69336008	19	10	1	17
2	.06535504-	.44841210	.55614189	.68975346	20	10	1	17
44	.08022202-	.45254996	.56377903	.70234631	21	10	1	17
34	.08816290	.45746264	.55351687	.66973976	22	10	1	17
27	.05584178-	.45957532	.55777760	.67696378	23	10	1	17
41	.05479059-	.46151275	.54918096	.65350248	24	10	1	17
46	.04929272	.46323474	.54966403	.65221910	25	10	1	17
45	.05433668-	.46530251	.55467931	.66122388	26	10	1	17
39	.05535983	.46709203	.57043472	.69664166	27	10	1	17
44	.05224083-	.46889343	.57540805	.70611871	28	10	1	17
46	.05310932	.47077355	.57592852	.70457156	29	10	1	17
50	.04787796	.47229918	.57871025	.70909614	30	10	1	17
36	.05807056-	.47447635	.58620714	.72424855	31	10	1	17
30	.04729292	.47585842	.59416654	.74188846	32	10	1	17

Models for Air Force Management

The problem of manning the Air Force is analogous to the logistics of supply where mathematical models have provided the means of simulating the operation of a dynamic system. The Air Force first called on operations research experts for a solution of the personnel assignment problem. This line of investigation was particularly fruitful in providing a feasible way of reconciling quota and personnel qualification requirements.

This success suggested that mathematical models might be adapted to simulate the Air Force personnel system. From one of these models, a general model of the airman population was developed and tested in a feasibility study. This model, based on Markov chains, differentiates the airmen into groups, or "states," based on characteristics that determine job functions in the Air Force. It permits projections to future points in time of the number of airmen in each state, and comparison of these projected numbers with the needs forecast to exit at that time. When the forecast and estimated need are widely different, a policy change is simulated and the effect evaluated.

One small part of this model (which represents the Electronics Operations group of career fields) is shown schematically in Figure 8. Figures in the table under the diagram show effects of (a) continuing present personnel policies; (b) adjusting the rate of input; and (c) adjusting retention at the end of the first enlistment. With each change, the expected numbers correspond more and more closely to forecast needs.



	GRADE GROUP	EXPECTED NUMBER	FORECAST NEED	DIFFERENCE	PER CENT OF NEED
CONTINUE	A/B - A/2C	24386	17521	+6865	139
A	A/1C & SSGT	15625	20467	-4842	076
POLICY	TSGT & M/SGT	10536	9122	+1414	115
CHANGE	A/B - A/2C	17718	17521	+ 197	101
TO B	A/1C & SSGT	13689	20467	-6778	066
POLICY	TSGT & M/SGT	10536	9122	+1414	115
CHANGE	A/B - A/2C	18466	17521	+ 944	105
TO C	A/1C & SSGT	18919	20467	-1548	092
POLICY	TSGT & M/SGT	12017	9122	+2895	131

Fig. 8. Simplified model of one group of career fields.

This model was developed to make a practical test of the theoretical model. It has passed that test, and now administrators are deciding what characteristics to include in the model and the necessary procedures for swift and continuous data collection.

An extension that appears promising is the combination of this type of model with others to permit the selection of a "best" or "optimum" policy.

Personnel research is, by its nature, undramatic. There are no tense countdowns or spectacular captures of vehicles returning from space. On the other hand, methods for meeting the personnel demands of a new Air Force system emerge from investigation of the system in being. The rapidly increasing complexity of equipment resulting from technological advances requires highly competent personnel to design, operate, and maintain the systems. Improved techniques of job description, personnel selection, and assignment are necessary to meet these demands. Readiness for the new comes from increased precision and speed of collecting information, making predictions, and verifying these predictions. This series of successive refinements provides the means of keeping up with increasingly demanding Air Force personnel needs—never perfectly, but always closer to the optimum.

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6570th Personnel Research Laboratory (AMD), Lackland AF Base, Tex.
Rpt No. PRL-TDR-63-5. SURVEY OF TESTS USED IN AIRMAN CLASSIFICATION. Feb 63, vi + 31 p. incl tables, illus, 31 refs. Unclassified Report

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1 Aptitude tests
2 Classification
3 Selection
4 Aviation personnel
5 Psychometrics
6 Test construction (psychology)
7 Standardization
I AFSC Project(Task) 7717(05)
II W.B. Lecznar
III Aval fr OTS
IV In ASTIA collection

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Aptitude tests have been used since 1948 to aid in selecting and assigning enlistees to the training for which they are best suited by ability and education. By this means the Air Force seeks to reduce the cost of training and realize competent, well-satisfied career airmen. This survey traces the history of airman aptitude testing, tells how effective tests are identified, how the tests are assembled, and how the scores are used. The present Airman Qualifying Examination is described and compared with other aptitude test batteries. The role of research in seeking out more effective techniques of personnel selection and assignment is emphasized, with illustrations from ongoing studies.

1 Aptitude tests
2 Classification
3 Selection
4 Aviation personnel
5 Psychometrics
6 Test construction (psychology)
7 Standardization
I AFSC Project(Task) 7717(05)
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